10

(12) 16p.

UNITED STATES ARMY AVIATION TEST BOARD
Fort Rucker, Alabama 36362

(11)

STEBG-TD

10 DEC 1963

SUBJECT: Report of Operational Tests Conducted by the US Army Aviation Test Board, USATECOM Project No. 4-3-3150-01, (6) "Engineering/Service Test of AN/GRN-14() Position Fixing and Navigation System (PFNS)"

TO: Commanding General
US Army Electronics Proving Ground
ATTN: STEEP-EM
Fort Huachuca, Arizona 85613

1. Transmittal. Submitted herewith is subject report of tests.

2. Discussion.

a. The US Army Test and Evaluation Command (USATECOM) test directive for the engineering/service test of the AN/GRN-14() PFNS, a prototype development model, designated the US Army Aviation Test Board (USAAVNTBD) as a Participating Test Authority (PTA) with the US Army Electronic Proving Ground (USAEPG), Fort Huachuca, Arizona, designated as Coordinating Test Authority (CTA). The USAAVNTBD was directed to conduct those tests necessary to determine the suitability of PFNS for use by Army aviation. The USAAVNTBD invited the US Army Aviation Human Research Unit (USAAHUMRU) to participate in the service test; their report is contained in Section III of inclosure.

b. The concept of a low-frequency, hyperbolic navigation system, for the use of Army aviation, was evaluated by US Army Europe, during their test of the Decca Navigation System in 1959-1960. Hyperbolic grid navigation systems, Decca being but one type, are presently being used throughout the world and have been for more than twenty years.

c. Representatives of USAAVNTBD went to USAEPG, Fort Huachuca, Arizona, in March 1963, to observe static engineering tests, and to perform operational tests when PFNS was moved to the field in late April. During the period April-August 1963, there were numerous problems and malfunctions of the transmitters and the airborne/vehicular receivers, major problems being the lack of Lane Identification and system reliability. The results obtained during this period were minimal and, in many areas, inconclusive. About 1 August, the complete PFNS system was returned to Bendix-Pacific for modification.

d. After numerous modifications, the system was returned to the Army on 23 September for resumption of the test. The modifications to the transmitters and receivers improved the operation of PFNS to some extent, but did not yield the required system reliability. One flight would yield very accurate results, but the next flight would give very poor results. This variation in results and accuracy was due to many causes. Some of these causes were malfunction of transmitters and/or receivers, inaccuracies of the plotted PFNS grid on the maps, and anomalies that existed in radiated pattern due to terrain and propagation phenomena.

3. Test Results.

a. Excessive time was required to prepare the plotter charts.

b. The plotter charts greatly limited the aviator's flexibility in accomplishing his mission. The eleven inches of plotter chart could represent a distance varying from a few hundred yards to several miles. This distance varied with position in the PFNS pattern and with the pattern of plotter charts used. If the aviator received instructions to proceed to a different destination or by a different route, the chart he had plotted could not be used, and he had to resort to manual plotting, using maps overprinted with the PFNS grid. This was impracticable and unmanageable. A coordinate converter or equivalent equipment which would permit the use of standard aeronautical charts and tactical maps in the display would alleviate this situation.

c. The unreliability of the system required the aviator to devote excessive time to checking and updating the equipment during flight. This division of his attention from the flight instruments created an unsafe condition, especially during nap-of-the-earth flight.

d. By using PFNS, aircraft were flown within airway limits, and locations over checkpoints were determined as accurately as with present navigation systems, WHEN the radiated pattern was stable, the transmitting and receiving sets did not malfunction, and the plotter chart was accurately drawn.

e. The loss of reception of one slave station seriously hampered mission completion. The loss of two slave stations prevented mission completion when PFNS was the only means of navigation.

f. The use of AN/GRN-14() PFNS equipment as the only aid to navigation to make IFR flights, flights to remote areas, and approaches to a destination airport under weather conditions of reduced ceiling and visibility was not practical because of transmitter and receiver unreliability and poor repeatability.

g. Because of the size and weight, installation of the PFNS equipment in an OV-1() surveillance-equipped aircraft (SLAR-IR) was impossible.

h. The US Army Aviation Human Research Unit found that the "PFNS aircraft display unit is totally unsatisfactory from the human factors standpoint."

4. Conclusion. The AN/GRN-14() PFNS as tested for Army aviation use was not ready for service test.

5. Recommendations. It is recommended that:

a. The AN/GRN-14() PFNS as furnished for this test be given no further consideration for Army aviation use.

b. Any redesigned PFNS equipment satisfactorily pass engineering test prior to initiation of service test.

A. J. RANKIN
Colonel, Armor
President

1 Incl
as

Info copies:
Hq, USATECOM

UNITED STATES ARMY AVIATION TEST BOARD
Fort Rucker, Alabama

SECTION I - TEST DATA

Subtest No. 2 - Instrument Flight Rules

a. Purpose. To determine if the system can be used as a sole means of navigation under instrument flight rules (IFR) conditions.

b. Criteria. The PFNS shall provide a means of navigating an aircraft under instrument flight conditions from climbout, enroute, and to approach. The accuracy shall be comparable to currently used navigation systems.

c. Discussion of Test.

(1) Routes Flown. There were two routes used for the IFR test flights.

(a) The first route was from Libby Army Airfield directly to Mescal Intersection, V66 to Tucson VOR, V16 to Phoenix VOR, V105 to Prescott VOR, and then an approach to Prescott Municipal Airport. After a low approach, the route was flown back to Libby AAF. This route was flown five times in a U-6A airplane (one night flight).

(b) The second route was from Libby AAF directly to Mescal Intersection, V66 to Yuma VOR, and an approach to Laguna AAF. After a low approach the route was flown back to Libby AAF. This route was flown four times in a U-6A aircraft; one night flight was made in a U-1A.

(c) The requirement to draw the master plotter charts (from which the charts used were duplicated) was placed on the correlator section. The cartographer who prepared the charts was highly experienced. Only one cartographer could work on a chart at a time. To obtain the desired accuracy the cartographer spent approximately 90 man-hours (during two weeks) to prepare the two charts for the routes flown. The route to Prescott was 232 n.m., and the route to Laguna AAF was 264 n.m. The finished plotter chart was approximately 15 feet long.

(2) Prescott Flights.

(a) The first two flights to Prescott revealed a charting error in the location of the VOR and airport. After this section of the plotter chart was redrawn, better results were obtained on the third and subsequent flights in making an approach to the airport.

(b) On all flights to Prescott using PFNS, the aircraft was kept within the airway boundaries. On those flights where there was little or no trouble with the equipment, it was noticed that the recording stylus was more sensitive to deviations from course than the VOR needle. On most flights, PFNS would indicate station passage over a VOR within 50 yards (obtained by noting station passage on the VOR indicator and a visual reference to the VOR transmitter on the ground). In determining intersections on the airway PFNS was as accurate as the VOR indicator.

(c) Best results were obtained on the fifth flight. After a low approach, which brought the aircraft within 100 yards of the runway centerline, the aircraft was flown to Wickenburg, off the plotter chart, to pick up a passenger, and was then flown to intercept V105 between Rock Spring and Cave Creek Intersections. The equipment lost a few lanes, but when it was updated using the Lane Identifiers (LI's) it tracked very well back to Libby AAF. It was noted that all intersections and stations were recorded very closely to their true position.

(d) On all flights the aviator had to devote 75 to 90 percent of his attention to PFNS computer display unit (CDU).

(e) Two flights could not have been completed under actual instrument conditions.

(3) Yuma Flights.

(a) The flights to Yuma yielded consistently poor results. On three of the flights, fair results were obtained enroute with intersections and stations recorded close to their actual location. While the aircraft could be kept on the airway by using PFNS it could not have been used to make a flight to Laguna AAF under instrument flight conditions. An approach to Laguna AAF using PFNS was impossible on all flights. This may have been due to charting error and pattern shifts in that area.

(b) On these flights 90 percent of the aviator's time was devoted to checking and updating the CDU.

(c) None of these flights could have been completed under actual instrument conditions.

d. Findings.

(1) Too much time was required to draw the plotter charts.

(2) The plotter charts limited the aviator's flight path to that plotted. If ATC clears the aircraft by a different route or to an alternate airport, then the chart previously prepared is unusable.

(3) On all flights the aviator had to devote too much of his attention to checking and updating the CDU.

(4) By using PFNS, aircraft were kept within airway limits, and locations over checkpoints were determined as accurately as with present navigation systems, WHEN the radiated pattern was stable, the transmitting and receiving sets did not malfunction, and the plotter chart was accurately drawn.

(5) Accurate approaches to the destination airport could not be made consistently with the equipment tested.

c. Conclusion. Because of the combination of transmitter and receiver unreliability, repeatability error, and probable mapping and PFNS grid errors, AN/GRN-14( ) PFNS cannot be used as the sole means of navigation under actual instrument flight conditions.

Subtest No. 3 - Air Traffic Control Test

This subtest was not accomplished because of the lack of air traffic volume and operating personnel to conduct the test.

Subtest No. 4 - Aerial Positioning for Surveillance

This subtest was not conducted. A thorough investigation by engineers of the US Army Aviation Test Board determined that installation space was not available in the cockpit and the electronics compartment of the "B" and "C" model OV-1 for the present configuration of the AN/GRN-14( ) PFNS airborne receiver.

Subtest No. 5 - Minimum Chart Requirements

a. Purpose. To determine the minimum plotter chart requirement for airborne use in the field army.

b. Criteria. None established. A determination shall be made on the number and configuration of plotter charts for general aviation use.

c. Discussion.

(1) The minimum plotter chart requirements per individual aviator for AN/GRN-14( ) PFNS operations in the field army area are estimated to be six mylar plotting rolls of four charts each, two of the charts on each roll being of 1- and 2-lane increments, and the remaining two charts being of 3- and 6-lane increments. The 90-, 60-, 45-, and 30-degree pattern should be selected. This will give each aviator a primary chart, a secondary chart, and two skew charts for

plotting in six possible combinations to cover the area for approximately 90-percent of his mission.

(2) In view of the massive training problem involved with each aviator in an aviation unit, the unit operations section should include a PFNS plotting team. This team would plot master charts for all area missions. The individual aviator assigned to fly a mission would then plot his chart by the overlay method from the master chart using pencil or other manner to permit cleaning and reuse of his charts. The use of master charts would prevent having to schedule the same pilot for each recurring mission, and would result in a savings of time in getting the flight off the ground. As a further aid in updating the master charts the aviator could transfer culture and other items of interest to the master charts at a post-mission briefing.

d. Conclusions.

(1) It is not possible at this time to estimate the master chart requirement for even a division aviation battalion.

(2) Based upon the above discussion and findings of Subtests 2 and 7, a coordinate converter or equivalent equipment is needed which would permit the use of standard aeronautical charts and tactical maps.

Subtest No. 6 - Loss of Reception

a. Purpose. To determine the effect of loss of reception of one or more slave transmitters on air navigation.

b. Criteria. The PFNS shall provide enough information to allow the pilot to navigate a reasonably accurate course comparable to that possible when using a magnetic compass not annually compensated.

c. Method.

(1) On nearly every flight during the period May through June 1963, at least one slave station became inoperative, thus giving data for this subtest. In addition, the daily electrical storms in the area caused the receivers to break lock frequently or become so erratic that it was impossible to navigate with PFNS.

(2) Flights were conducted in OV-1 and USAF C-130 type aircraft. The flights were conducted under both VFR and IFR (dry) conditions in the Fort Hauchuca local area, and over a route from Libby AAF to Las Vegas, Nevada, and return. The altitudes ranged from 100 feet absolute to 22,000 feet m.s.l.

d. Findings.

(1) All PFNS plotter charts are prepared using only two slave stations (designated by colors) plus the Master station. When one of the two slave stations programmed went off the air, tracking became erratic and the position lane indicator (PLI) readout information for that slave station was unreliable.

(2) Most actual missions could not be completed using PFNS when reception of one or more slave stations was lost.

e. Conclusions.

(1) Loss of reception of one slave station can hamper completion of a mission if the aircraft is located within certain areas of the pattern in relation to the lost station.

(2) Loss of reception of two slave stations will prevent completion of a mission if AN/GRN-14() PFNS is the only means of navigation.

Subtest No. 7 - Remote Area Landing

a. Purpose. To determine if the PFNS can be used as a sole means of navigation in takeoff, enroute, and on the approach to a remote area.

b. Criteria. The position information gained from the PFNS airborne receiver shall be sufficient to permit safe takeoff, navigation, and approach to a designated remote landing area while engaged in instrument flight having minimums of 300 feet ceiling and 3/8-mile visibility both at takeoff and landing.

c. Method.

(1) This test was conducted using Kearney Airport (approximately 90 n.m. NNW of Libby AAF, Fort Huachuca) and two strips in the South Range area of Fort Huachuca. A total of seven flights were made to Kearney Airport, two of which were at night. A U-1A was used for one flight, and a U-6A for six flights. Five flights were made using the strips in the South Range. Two of these flights were made in a UH-19D and the remainder in a U-6A. No night flights were made in this area due to the close proximity to the Huachuca Mountains and the poor results obtained during the daytime.

(2) Approximately two weeks were required to draw the plotter charts.

d. Discussion.

(1) The first two flights to Kearney Airport revealed a charting error in the position of the airport. On all flights to Kearney Airport, excellent tracking and positioning over plotted landmarks were obtained. After replotting the airport, a maximum error of 100 yards, with the average between 25 and 50 yards, was recorded during low approach to the airport. Upon return to Libby AAF, the aircraft was within 100 yards of the runway centerline. On a few flights, the aircraft was brought down the center of the runway.

(2) The accuracy obtained at Kearney Airport was due primarily to the proximity to the Green baseline. The variations recorded at Libby AAF could be due to pattern shifts and anomalies in the area.

(3) Fifty to seventy-five percent of the aviator's time was spent checking and updating the computer display unit (CDU).

(4) The flights to the strips in the South Range were consistently off the desired ground track. Some destination errors were as large as one mile. If PFNS had been followed without visual reference to the ground, the aircraft could not have been flown out of the canyon in which one of the strips was located. The errors on these charts could have been due to a shift of the PFNS grid from that printed on the 1:50,000 maps of Fort Huachuca. It was noted that the strips and Libby AAF did not consistently fall in the same place on the plotter charts.

(5) Eighty to ninety percent of the aviator's time was spent checking and updating the CDU.

e. Findings.

(1) Too much time was required to draw the plotter charts.

(2) The plotter charts greatly limited the aviator's flexibility in accomplishing his mission. The eleven inches of plotter chart would represent a distance ranging from a few hundred yards to several miles. The distances varied with his position in the pattern and with the pattern of the plotter charts that were used. If instructions were received to proceed to a different destination, the chart plotted could not be used, requiring manual plotting with maps overprinted with the PFNS grid.

(3) The unreliability of the system during the test required the aviator to devote too much time to checking and updating the equipment. This division of his attention from the flight instruments created an unsafe condition, especially during nap-of-the-earth flight.

f. Conclusion. With present equipment, flights to remote areas are not practical under the criteria set forth in the test plan (30 feet ceiling and 3/8-mile visibility). The combination of transmitter and receiver unreliability and probable mapping errors which contribute to the reduced confidence level of the aviator drastically limits the application of PFNS to such flights.

Subtest No. 8 - Manual Plotting (Aircraft)

a. Purpose. To determine the feasibility of manual plotting of an aircraft position on an extended flight.

b. Criteria. The system shall provide suitable position information so that the aviator may plot his position manually on a chart imposed with a PFNS hyperbolic overlay.

c. Method. Two flights were made to gather data for this test. The first was in a U-1A using 1:50,000 maps overprinted with the PFNS grid, and the second flight was in a USAF C-130 from Libby AAF to Laguna AAF. The aircraft position was plotted every five minutes for forty-five minutes using 1:250,000 maps.

d. Findings.

(1) Accurate positions could be plotted on 1:50,000 maps; however, this scale map was too unwieldy for use in the cockpit.

(2) Satisfactory positions could be plotted using the 1:250,000 maps.

e. Conclusion. Manual plotting is feasible but impractical to determine position and to navigate on an extended flight.

Subtest No. 9 - Comparison Test

This subtest was deleted because of the consistent inaccuracies obtained in previous tests.

Subtest No. 10 - Re-Orientation by Position Line Indicators and PFNS Map

a. Purpose. To determine the feasibility of reorientation and navigation to original destination by using position lane indicator and PFNS map.

b. Criteria. The receiver shall provide usable position information so that a disoriented pilot can determine his true position and navigate to his original destination using position lane indicators and PFNS map.

c. Discussion.

(1) Two flights were made in a UH-19D in conjunction with the Long Range Patrol Test. Maps of 1:50,000 for the Fort Huachuca area were used to orient and navigate the helicopter when dropping and picking up the patrol.

(2) An extended flight in a U-6A was attempted using only PLI and PFNS maps. Because of malfunction of the airborne receiver and unknown activity by the ECM team, no useful data were collected.

(3) Subtest No. 8 has a correlation with this test.

d. Findings.

(1) Approximate position could be determined using the PLI and a PFNS map.

(2) Navigation from one point to another could be accomplished using only the PLI and PFNS map; however, this was an unwieldy operation because of the size of the map which was aggravated if more than one map was required for the flight. A high degree of accuracy cannot be expected with this method; however, using this method of orientation and navigation, the aircraft could be flown to within visual contact of a desired location (to an area).

e. Conclusion. It is feasible to reorient an aircraft and to navigate to a desired area using only PLI's and PFNS map. Because of the unreliability of the test equipment, this procedure should not be followed over unfamiliar terrain or under conditions of reduced visibility and ceiling.

Subtest No. 11 - Utilization of Airborne Receiver in an Armed LOH Aircraft

a. Purpose. To determine the stability of the airborne receiver in an armed rotary-wing aircraft during maneuvers and firing in the accomplishment of a combat mission.

b. Criteria. The display system shall be able to withstand the stresses caused by the maneuvers and firing of the guns without damage to the equipment. The plotter shall produce a clear, readable tract at all times with no slippage during violent phases of the maneuvers. The equipment shall have an accuracy sufficient to allow the pilot to deviate from his proposed route of flight and to remain oriented at all times.

d. Method. Two flights were made with a PFNS receiver and computer display unit mounted in an armed UH-1B helicopter. Various flight attitudes and maneuvers were performed at speeds of 0 to 130 knots, including live firing runs.

d. Findings.

(1) The helicopter vibrations in flight had no adverse effects on the PFNS equipment, and in particular upon the stylus tracking of the CDU.

(2) During the firing of the armament subsystems, the stylus deflected to the right or left (predominately to the right) one-sixteenth of an inch, and held the deflection until firing stopped. This small deflection could be caused by the electrical field set up by the heavy duty solenoids used to activate the armament subsystem during firing.

e. Conclusion. Maneuvers and firing by an armed helicopter have no adverse effects upon the PFNS equipment. The small deflection noted would not affect the useful employment of PFNS since the firing occurs in the target area, and the stylus returns to the track for the departure from the area.

SECTION II

Deficiencies and Shortcomings

A. Deficiencies.

Deficiency	Recommended Corrective Action	Remarks
1. Cross-checking and updating the computer display unit (CDU) requires excessive time.	Automatic updating should be designed into future receivers.	Automatic updating is mandatory in one-man aircraft or high-performance aircraft.
2. Plotter charts require too much time to prepare and greatly limit aviator's flexibility in mission accomplishment.	Incorporate a coordinate converter, or similar equipment to permit the use of standard aeronautical charts and tactical maps.	Use of standard maps will aid swift mission reaction time, require less operator training, and delete requirement for a section of cartographers to prepare plotter charts.
3. Transmitters and receivers are not reliable.	Increase equipment reliability.	Equipment should be at least as reliable as current navigation equipment.
4. Airborne equipment is not compatible in size and weight with present and proposed Army aircraft.	Reduce size and weight.	

B. Shortcomings.

Shortcoming	Recommended Corrective Action	Remarks
1. CDU occupies too much panel space and some controls are inaccessible.	Repackage CDU into a plotter assembly and separate computer/control unit.	

Shortcoming	Recommended Corrective Action	Remarks
2. Single no-signal-warning (NSW) light gives no indication of which transmitter has malfunctioned.	Provide a positive NSW light for each transmitter.	
3. Flight charts are difficult to load.	Design a rapid-loading method for the charts.	Such a method is necessary to permit change of charts in flight.
4. Negator springs break or come off spools.	Replace or redesign chart rewinding mechanism.	
5. Stylus positioning control ("joy" stick) will not move charts or stylus when set is in the "receive" position.	Redesign circuitry so that stylus and chart can be moved when set is in the "receive" position.	Corrective action is necessary so that stylus can be positioned while set is warming up or in case the transmitters have lost lock.
6. Fast lock function missing if no chart head in CDU.	Reposition fast lock switch from chart head to computer unit.	For some missions, a chart will not be required, but fast lock function is needed during warmup.
7. Switches on the digital display unit are too fragile.	Replace with switches having shorter handles that are more rugged.	
8. Tracking stylus clogs easily and is very difficult to fill with ink.	Replace capillary pen with a more reliable recording device which is easier to load.	

SECTION III

U. S. ARMY AVIATION HUMAN RESEARCH UNIT
Fort Rucker, Alabama

13 November 1963

Human Factors Evaluation of the PFNS Navigation System Aircraft Display Unit

1. The PFNS aircraft display unit is totally unsatisfactory from the human factors standpoint. The units presented for evaluation were far below minimum standards for present-day navigation equipment.

2. The human factors deficiencies of the PFNS display are, in large part, due to unsatisfactory contractor performance, but it is also apparent that failure of the Army to provide early and consistent professional human factors monitoring of the display development has contributed materially to its present unsatisfactory state.

3. This paragraph will confine itself to major deficiencies of the PFNS aircraft display which are general in nature.

a. The general lack of reliability of the present equipment precludes the pilot confidence required for operational use of this type of navigational system. To be used for tactical operations at low altitude in rough terrain, it is essential that the system have a reliability better than most past navigational systems.

b. The PFNS display unit appears to have been developed without consideration given to the panel space available in Army aircraft, except for late in its development when trying to fit the bulky display unit into Army aircraft was finally given consideration. Consideration of space demands in the Army aircraft cockpit indicate that the present display unit should be divided into three units, (1) a relatively compact digital display unit and control head, (2) the plotting chart designed so that it may be placed and used in an approximately horizontal position behind the glare shield or as a lap unit, and (3) a third unit placed behind the panel containing electronics presently incorporated into the display unit.

c. The PFNS chart requires excessive planning time for its successful use in a tactical environment. A rapid response time of several minutes is impossible using the charts, and attempting to set up a chart within an hour or two requires quick estimates which will increase the operational error associated with chart usage.

d. Use of the charts during flight requires excessive attention on the part of the pilot. It should be noted that it may be possible to accomplish practically all tactical missions by utilizing only the digital display counters. Almost all planning time would be eliminated and in-flight attention requirements would be considerably reduced.

e. The lack of directional and distance reference in using the system is a serious drawback for operational use. The pilot needs something "on which he can hang his hat," and when direction and distance units have no definable values in referring to the terrain, serious operational confusion is inevitable. The present highly distorted topological representation of terrain is unsatisfactory for Army aviation use. An X-Y converter appears required to avoid the confusion resulting from lack of reference values. This converter would make possible direct communication and employment using the military grid reference system, and should also permit the use of standard tactical maps in the plotting unit. These features would greatly enhance the tactical employment of the system in Army aircraft.

f. In its present form, the equipment is extremely inflexible. You are committed with the established chart program. Therefore, the system cannot be relied upon for use in a rapidly changing tactical environment where changes in plans may frequently be required. Failure during flight to change chart programs at exactly the specified point may result in considerable effort being required to get the plotting unit back on the programmed schedule.

g. The aircraft display lacks positive indications required for Army aviation use. Many of the indications are subject to ambiguities and uncertainties which must be resolved by the operator. These resolutions require considerable mental attention and manipulations which should not be imposed on a pilot operating at low altitudes. All information with the exception of the plotting bug should be made positive in nature by automatic updating rather than by actions and decisions on the part of the crew.

h. The aircraft display unit was generally poor in regard to the particular characteristics of controls, displays, and lighting.

4. This paragraph lists specific deficiencies or shortcomings of the PFNS aircraft display unit and the operations associated with its use.

a. The maps providing the PFNS grid overlay are reproduced in black and white. This makes them cluttered and difficult to read, particularly when the PFNS grid overlay is added to the clutter.

b. Due to the clutter it is difficult to determine the PFNS coordinates of a given geographic feature. When the PFNS coordinates intersect at a small acute angle, determining PFNS coordinates is particularly difficult.

c. Selection, programming, and annotation of charts is a difficult and time-consuming process that will not be practical under tactical conditions requiring rapid response.

d. The chart requires an excessive amount of care for its insertion in the plotting unit.

e. Changing the plotting unit in flight requires an excessive amount of manipulation on the part of a single crew member. If alone, a pilot will probably have to land his aircraft in order to accomplish a plotter change.

f. If not inserted properly the chart may bind, leading to the driving sprockets ripping the chart and precluding accurate advance.

g. Successful chart code changing while in flight demands excessively accurate position at the time of the change, and the code change to be accomplished exactly at the moment indicated by the chart.

h. Overall, the contribution of the plotting unit to tactical effectiveness does not appear to warrant the problems which it generates. If the system had satisfactory reliability, the most useful aspects of the plotting chart would be when following special routes or corridors, or when using it for a low approach to a laning area under IFR conditions.

i. The X-Y plotter switch circuitry should be redesigned so the chart may be moved while the unit is in operation.

j. It is doubted that both PFNS coordinate and X-Y coordinate plotter slewing switches are justified by the additional performance capability resulting from both types. A single eight-position slewing switch would appear satisfactory for accomplishing required slewing.

k. The plotting unit should be removed from the combined present display unit, and designed so that it may operate in either vertical or horizontal orientation as either an aircraft-mounted or lap-mounted display unit.

l. Numerous slewing switches were too long and fragile. Normal switch pressures resulted in their damage, and a resulting difficulty in their subsequent use.

m. Some of the push buttons were excessively small in diameter for the amount of pressure required against them. They also provided no action feedback to the operator other than by visual monitoring of the appropriate counters.

n. Counters were found to occasionally hold with a between-digits position centered rather than one of the digits being centered. This resulted in ambiguity as to which digit was correct, and was found at positions other than the units counter.

o. The screens over the lane identifier counters were erratic in operation. The requirement for this set of lane identifier indications should be eliminated from the display by making the lane and line counters positive in their indication. The ambiguity of the present position counters contribute significantly to the difficulty of using the equipment. Present requirements for crew resolution of these ambiguities should be eliminated.

p. The no-signal warning light and the frequency-shift warning light should be changed from red to amber and provided with intensity controls. Preferably the intensity should be regulated through the regular panel intensity control switch. The frequency-shift warning light and the fast-lock switch should be moved onto the digital display unit or near the code selector unit. The no-signal warning light should be divided into three separate lights--one for each channel--in order to avoid the ambiguity associated with the present warning light. These should be placed adjacent to their respective counters.

q. The code-input switch should be provided or redesigned with some positive indication of code insertion. The On-Receive-Plot-Dimming function selector switch should be changed to a pointer-type rather than a skirted circular type of knob. The extra detent position in the plotter dimming range should be eliminated. Provision for dimming on the digital display unit should be provided, preferably on the regular cockpit dimming switch.

r. Intensity of illumination varied excessively over the display unit. The X-Y slew and code selector illumination was considerably brighter than that of the digital position counters, and would probably interfere to some extent with reading the counters. Illumination on the plotting unit falls off rapidly away from the row of lamps. A more even illumination permitting utilization of the entire chart would be desirable.

s. The ink-filling plotting pen is regarded as excessively messy. A dry process plotter, if practical, would be desirable.

t. The aircraft display unit using hyperbolic coordinates lacks the flexibility required for Army aviation operations. The lack of direction or distance reference makes it difficult for the aviator to plan in PFNS coordinates while in flight. It will not be practical with PFNS to attempt the in-flight planning that is frequently required in Army aviation operations.

/s/ Robert H. Wright
/t/ ROBERT H. WRIGHT, Ph. D.
Research Scientist